

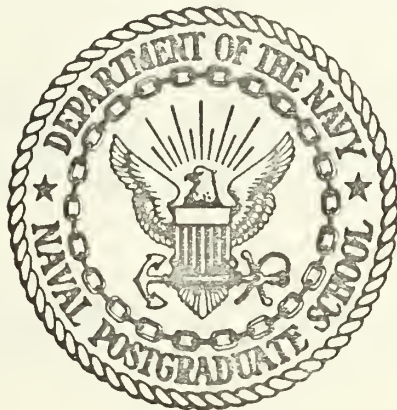
A MONITOR FOR THE PDP-8/S COMPUTER SYSTEM

by

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THESIS

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Glenn Tracy Martinsen

June 1970

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A Monitor
for
the PDP-8/S Computer System

by

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Lieutenant Commander, United States Navy
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ABSTRACT

The design and implementation of the PDP-8/S Monitor is described. The monitor is an interactive tape driving routine combined with a small operating system. The monitor was implemented in PAL III, the PDP-8 assembly language, for operation in conjunction with a teletype and PI-1250-1 Data Handling System.

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I. INTRODUCTION

The PDP-8/S¹ computer is input/output bound when the only peripheral device is a teletype and paper punch/reader unit. The addition of a tape drive, tape controller, and monitor software improves the overall capability of the system.

This thesis describes the development and implementation of an interactive tape driver system and small operating system. In order to produce a basic monitor system in a reasonably short length of time existing PDP-8 software was utilized where practical and manufacturer's design recommendations were followed when feasible. The steps taken to implement a monitor were: (1) gather and study available literature concerning the PDP family of computers; (2) decide on internal core paging requirements; (3) write elementary programs for the monitor; (4) write input and output routines for the teletype; and (5) write input and output routines for the tape system.

A basic knowledge of PDP-8 assembly language [Refs. 1 and 2] is essential to a clear understanding of this thesis. The conventions, abbreviations, and descriptive terms contained herein are those found in [Refs. 1-5].

¹The PDP-8/S is one of a family of small computers called PROGRAMMED DATA PROCESSORS manufactured by DIGITAL EQUIPMENT CORPORATION, Maynard, Mass.

II. DISCUSSION OF COMPUTER AND TAPE SYSTEMS

The computer system was configured with a PDP-8/S computer, a teletype with integral paper tape reader and punch, and a PI-1250-1 data handling system. This section will discuss each component of the entire system in relation to the requirements placed upon the monitor design.

A. PDP-8/S COMPUTER AND TELETYPE UNIT

The PDP-8/S is a general purpose digital computer operating on 12 bit binary words and having a four micro-second core cycle time. It is a single-address parallel machine using two's complement arithmetic. It is composed of four basic components:

- (1) Input/Output units; (2) Arithmetic unit; (3) Control unit; and
- (4) Memory unit.

1. Input and Output Units

Input and output devices are combined since many devices serve both functions. The primary input/output device is the teletype with integral paper tape reader/punch. All input or output associated with the teletype unit must be under program control and pass through the accumulator to be discussed later in this section. No direct transfer of information to or from memory is permitted. Because there is a great difference in the processing speed of the computer and the speed of most peripheral devices, the computer must be programmed to check the readiness of a device before any

transfer of information is performed. The PDP-8/S console allows the operator direct access to core memory and the program counter by setting a series of switches, enabling manual storage of programs and examination of information previously stored.

2. Arithmetic Unit

The arithmetic unit accepts data from input devices and transmits processed data to the output devices as well. Primarily, the unit performs calculations under the direction of the control unit. This arithmetic unit consists of a twelve bit register, called an accumulator, and a link bit. Bits are numbered from 0 to 11 starting at the left side of the accumulator and moving right.

The accumulator performs binary operations under the supervision of the control unit. Whenever the binary addition causes a carry out of the most significant bit, the carry is lost from the accumulator and causes the link bit to be set. The link bit is actually a one bit register logically attached to the accumulator. If a carry results from an addition in the accumulator, the link bit is complemented. This carry results in a link value change from 0 to 1, or 1 to 0, depending upon the original state of the link.

Positive numbers can be represented from 0 up to 3777_8 and negative numbers from -3777_8 up to -1. By convention, bit 0 specifies the sign bit (0 for positive and 1 for negative). In

decimal form then numbers from -2048 up to and including +2047 can be represented internally in a single twelve bit word.

3. Control Unit

The control unit is composed of three parts: (1) the instruction register; (2) the major state generator; and (3) the program counter. Together these registers follow what the computer is doing now and what it will do next, thus specifying the flow of the program from beginning to end.

The program counter is used to record the location in memory of the instructions to be executed. The counter always contains the address of the next instruction to be executed and normally, except in the case of branches, merely increments itself by one.

The instruction register is used by the control unit to specify the main characteristics of the instruction being executed. The first three bits (0-2) specify the operation to be performed and the remaining nine bits (3-11) specify the operand.

The major state generator establishes the proper states in sequence for the instruction being executed. One or more of the following three major states are entered serially to execute such programmed instruction. During a fetch state, an instruction is loaded from core memory, at the address specified by the program counter, into the memory buffer register. The default state is used in conjunction with indirect addressing to obtain the effective

address. The execute state performs the operation specified in the memory buffer register.

4. Memory Unit

The memory unit consists of 4,096 12 bit words of magnetic core memory, a 12 bit memory address register, and a 12 bit memory buffer register. Core memory is a form of random access storage, meaning any specific location can be reached in memory as readily as any other. Each word in memory requires a 12 bit address to specify the location uniquely.

The memory buffer register provides temporary storage prior to being used in the accumulator. Thus, the memory buffer holds all words that go into and out of memory, updates the program counter, sets the memory address register, and accepts information from or provides information to the accumulator.

The memory address register holds the address specified by a memory reference instruction. It is also used to specify the address of the next instruction to be brought out of memory and executed. The register can be used to directly address all of memory. It can be set by the memory buffer register, or by input through the program counter register, or by the program counter itself.

Since twelve bits are needed to address each word in core and only nine bits are available to specify an operand, core memory is divided into 40_8 pages of 200_8 words each. This arrangement allows bits 5 through 11 to be used to specify the desired address on the

current page. Bit 4 is used to specify an address on the current page by a 1 or on page zero by a 0. Bit 3 specifies whether direct addressing (set 0) or indirect addressing (set 1) is to be used. Table I demonstrates the paging scheme utilized in the PDP-8.

B. PI-1250-1 DATA HANDLING SYSTEM

The PI-1250-1 Data Handling System is a seven track magnetic tape system designed to operate with the PDP-8 family of computers. The system is composed of a PI-1207 RW Digital Tape Recorder and an interface device designated as an Information Controller unit, which contains the logic allowing data to be transferred to or from the computer under program control.

1. Data Representation and Transfer

Information records are written on tape in seven-bit characters composed of six data bits and an odd parity bit developed by the PI-1207 RW unit. All data is transferred from the computer to the tape except for parity, exactly in the character sequence as it appears in the accumulator; conversely, data is transferred to the computer exactly as it appears on tape.

All inter-record gaps must be recorded under program control; however, they are detected automatically causing certain bits in the status register to be set which can be examined under program control.

When reading data, two characters are read from the tape, assembled as a twelve bit word, and a data transfer request is

TABLE I
PAGING SCHEME FOR PDP-8

Page	Memory Location
0	0-177
1	200-377
2	400-577
3	600-777
4	1000-1177
5	1200-1377
6	1400-1577
7	1600-1777
10	2000-2177
11	2200-2377
12	2400-2577
13	2600-2777
14	3000-3177
15	3200-3377
16	3400-3577
17	3600-3777
20	4000-4177
21	4200-4377
22	4400-4577
23	4600-4777
24	5000-5177
25	5200-5377
26	5400-5577
27	5600-5777
30	6000-6177
31	6200-6377
32	6400-6577
33	6600-6777
34	7000-7177
35	7200-7377
36	7400-7577
37	7600-7777

initiated to place the word in the accumulator. When recording data, a twelve bit word is accepted, disassembled, and written as two six bit characters. Data can be transferred at incremental and slow speed to be compatible with the PDP-8/S. A high speed is used only with the controller's registers for searches and under monitor control.

Errors are handled through the logical structure of the controller. This includes the detection and reporting to the computer utilizing a program interrupt. These errors are:

(1) write or read operation unreadiness; (2) transfer rate errors; and (3) transfer data error (parity).

2. Information Controller

The information controller includes within its structure the means to receive, interpret, and retain commands; carry out a control operation; and notify or respond to the occurrences of a key event. The logical structure of the information controller is comprised of nine units.

a. Instruction Decoder

The instruction decoder provides the controller with the logical ability to receive a standard set of codes generated by the computer and decodes these signals into separate and mutually exclusive occurring commands to perform either a data transfer or to initiate, or suspend, an operation. The mnemonic code, octal code, and operation of all instructions is listed in Table II.

TABLE II
INSTRUCTION SET FOR INFORMATION CONTROLLER

MNEMONIC CODE	OCTAL CODE	OPERATION
PSSR	6701	Skip if system ready
PWMS	6702	Write mode select
PBOT	6704	Write beginning of tape
PSSF	6711	Skip on system flag
PREV	6712	Reverse read select
PFRD	6714	Forward read select
PSRF	6721	Skip on data rate error flag
PEOF	6722	Write End of file
PRDL	6724	Ready/Load
PSPF	6731	Skip on Vertical Parity error
PCLR	6732	System clear
PHLT	6734	Halt
PCHLT	6736	System clear/halt
PSDF	6741	Skip on data flag
PLMF	6742	Load memory Field Extension register and interrupt
PLDS	6744	Load data buffer register and step (write mode)
PRDS	6751	Read data buffer Register (Read mode)
PSER	6752	Skip if end of record flag
PSMS	6754	Slew mode select
PSSS	6761	Sense system status
PINS	6762	Incremental mode select
PREW	6764	Rewind select
PEOR	6771	Write end of record and halt
PHAS	6772	High speed accumulator I/O select
PERHS	6773	Write End of record/High Speed Accumulator I/O

b. Data Buffer Register

The data buffer register is a twelve bit register which serves as a buffer for data traffic between the tape and accumulator. This register is automatically cleared after a word is transferred to the tape unit or to the computer.

c. Read/Write Mode and Speed Select Register

This register receives direct commands from the instruction decoder to either start, maintain or suspend an operation related to one of three speeds and to either reading or recording.

d. Data Flag Register and Logic

This register is comprised of two bits, the read bit and write bit which, when set during programmed data transfer operations, communicate that the information coupler is ready for a data transfer with the computer.

e. System Status Register

The system status register is comprised of ten memory elements referred to as locks and identified as Vertical Parity Error, Data Rate Error, End of Record, End of Tape, Longitudinal Parity Error, Load Point, Beginning of Tape, Write Lockout Ring, End of File, and WCO Read.

Each of these possible conditions may be tested when the contents of the status register are transferred to the computer's accumulator. In addition console lights will be illuminated when any or all conditions exist. This enables a general program mask to be used and gives the operator the capability of reading the error from the console.

f. Reverse/Forward, Rewind and Ready/Load Register

This register controls the direction of the tape drive. Reverse and forward are complementary events and are implemented with a single bit. In addition the rewind lock is set by the occurrence of the rewind command and remains set until cleared by the halt or clear command or by the sensing of the beginning of tape reflective marker traveling past the photodetector. The ready/load logic task is to communicate to the read-write unit the proper commands at the beginning of an operation after initial tape mounting and threading.

g. Other Units

Three other components exist for high speed operation only and are not required for monitor operation. The PDP-8 does not have the capability to transfer or receive data at the rate described by this operational speed.

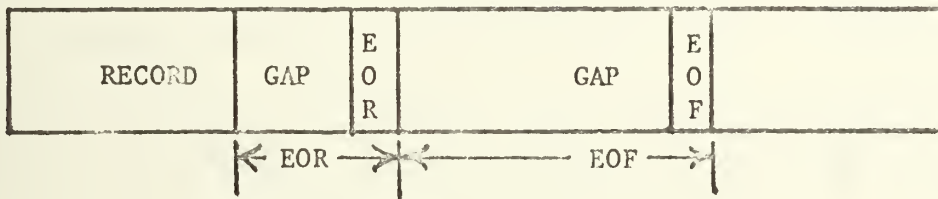
3. Gap Detection Logic

Gap detection logic included in the information controller continuously monitors the retrieved information to determine and indicate when a data record readout has concluded and, as a consequence, activates auxiliary logic to read the logical record control character (LRC), end of record (EOR), and end of file (EOF) characters without causing any operational ambiguities.

After the absence of two characters is determined, logic is activated to interrogate the validity of the LRCC character, and if an error is indicated the LRCC lock is set to communicate such an error through the status register to the computer.

To detect the end of file character, the gap logic retains in memory the fact that a single character record was read out, absence of two characters was determined, and if another character appears within the next two characters cell times, then it must be the LRCC character corresponding to the single EOF character.

The correct sequence for an EOR followed by an EOF is shown below.



III. DESIGN AND IMPLEMENTATION OF MONITOR

In any system that has more than one input/output device, the computer is required to handle many tasks almost at the same time in order to make the system function as a unit. A set of programs assigned the task of control and communications within the system is called the monitor.

The monitor is designed in such a manner so as to simplify the programming effort required by the user. It is not necessary for the user to have detailed knowledge of the entire system; but, instead, the user should have a general overall view of the computer and its monitor options. The monitor provides all the input and output operations and controls the message traffic between peripheral devices and the computer. System errors are detected by the

monitor and reported to the user eliminating the need for constant system checking by the user programs.

Many programs contained within the monitor may be called upon to serve user programs. These are normally input and output procedures and are all written as subroutines in this monitor to allow easy user access. Support programs are needed to install the monitor and keep it running smoothly. Normally the user will not need to call upon these routines. A third set of programs is necessary to assist the monitor in its assigned tasks. These procedures are written as subprograms within this monitor structure and are used to handle the pseudo commands available to the user.

Most programs written for the PDP-8 computer are loaded into core memory from paper tape punched in binary code. Many system programs, such as the editor and assembler routines, require as much as twelve minutes to read into memory. Through the use of a magnetic tape system, these same programs can be loaded into the computer in ten to fifteen seconds. This section describes the magnetic tape organization, the core memory requirements of the monitor, and the program specifications and conventions of the monitor.

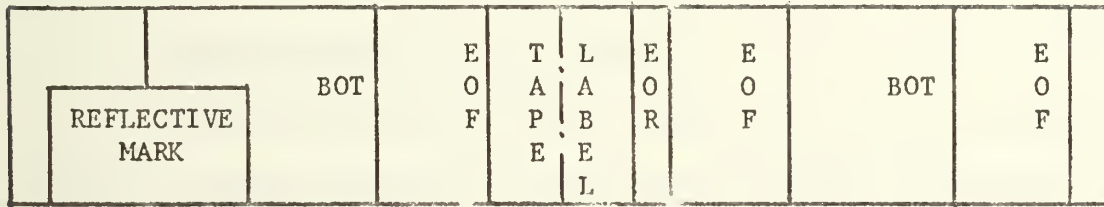
A. MAGNETIC TAPE ORGANIZATION

The magnetic tape is divided into four sections providing a logical arrangement for the files stored. These sections are:

- (1) Tape label;
- (2) Monitor;
- (3) System and user program library
- and (4) Scratch pad work area.

1. Tape Label

The tape label is required by the monitor to maintain a count of end of file marks appearing on the tape. The label is a one word (two character) file preceded by a beginning of tape gap (BOT) and end of file mark; and followed by EOR, EOF, BOT, and EOF. The label and appropriate gaps are depicted below.



The label is written in binary form as an octal number and can easily be located since it is the first record to appear on the magnetic tape. The BOT mark is a length of erased tape placed so as to give the read head a reference point from which to start. The second BOT is provided as protection for the programs recorded.

By reading the number written in the tape label an accurate count of the number of EOF marks appearing on the tape can be read to the computer. This number can then be used by the monitor to find the desired position to write a new record, to locate the scratch pad area, or to check for errors.

2. Monitor Storage

The monitor appears as the first complete program recorded on the tape. It is located immediately after the tape label with associated gaps. Since the monitor is the most frequently used program, it should appear close to the beginning of the tape for more rapid loading, minimizing the search time required.

It is unnecessary to read the tape label in order to load or store the monitor since three EOF marks always precede the monitor in its storage location. Any time the monitor is required, the tape label counter is generated by the program rather than by reading the label. Immediately following the monitor on tape an EOR and EOF are written to separate it from following files.

3. System and User Program Library

PDP-8 system programs appear immediately after the monitor on tape. Programs designed by users and to be added to the tape system are appended after system programs.

System programs are arranged in a logical sequence dictated by their normal usage in most programming efforts. Master tapes can be prepared with these programs placed in any order, but a suggested master tape system program sequence follows.

MONITOR
SYMBOLIC EDITOR
PAL III ASSEMBLER
ODT LOW
HELP BOOTSTRAP
USER PROGRAMS

This list places the most needed programs early on tape and then in order of their usage. For example, the Editor and Assembler are required equally but the Editor is normally used prior to the Assembler; thus, the ordering is as listed.

User programs follow no usage scheme as do system programs. Instead, user programs appear on tape in the order that they were

recorded without regard as to their potential usage. A new master tape can be generated at any time to order user programs as desired.

4. Scratch Pad Area

The user may at any time desire to utilize a scratch pad area of tape without engaging monitor or system programs. Immediately following the last program recorded approximately ten feet of blank tape is supplied as separator for system protection and an EOF is recorded marking the beginning of the scratch pad section. Return to this area can be accomplished programmatically by the user to recover data stored in that area.

Since no other safeguards exist for the system tape, the user must insure that no scratch pad recording is done prior to the designated portion of tape. Suggested methods for using the scratch pad section appear in Appendix A.

B. MEMORY REQUIREMENTS

The core memory of the PDP-8/S is restricted to 4,096 words and, as such, an executive routine must be extremely compact and limited in its scope. The monitor occupies pages 30_8 through 37_8 inclusive, or address 6000_8 through 7777_8 . In addition locations 0100_8 to 0141_8 are required only when loading the monitor, either under monitor control or by the bootstrap program.

The monitor is divided into two separate sections. Section I consists of pages 30_8 through 32_8 and Section II, the mini-monitor, of pages 33_8 through 37_8 .

1. Monitor-Section I

Section I of the monitor may be destroyed by the user without adverse effect upon the primary functions of the monitor. Loss of four commands from the code list will be experienced; however, all store, load, input and output routines will be retained in the mini-monitor. In addition the ability to regain the entire monitor rests solely with Section II. This feature enables the user more core memory space without undue loss of performance from the monitor system. The user commands as much of memory as is practical; page 0 except for locations 0100_8 to 0141_8 , thus retaining autoindexing registers at locations 0100_8 through 0017_8 as discussed in Ref. 1, the remaining pages up to 30_8 , and if desired up to page 33_8 . This memory area should be more than adequate for most programming efforts.

2. Monitor-Section II (Mini-Monitor)

Section II of the monitor contains the primary service routines normally required by users. Page 37_8 of the mini-monitor contains one PDP-8 system programs, the BIN loader. This program allows a user to load a binary paper tape into memory at the required locations.

If the user desires he may utilize all of core up to page 37_8 for his programming, resulting in destruction of the monitor. To reload the monitor in its entirety the recover procedure is utilized to read the entire monitor program into memory from magnetic tape. This is accomplished by setting 7600_8 into the switch register,

depressing load address, and start. Rewind must be executed manually by using the PI 1207 RW control panel.

C. PROGRAM SPECIFICATIONS AND CONVENTIONS

Twenty-nine separate programs and subroutines comprise the monitor. Fourteen subroutines are concerned only with input and output and are discussed in great detail in Appendix A. Eight subprograms are used to respond to requests given by the user and the remaining programs are utility routines integral to the monitor.

Each of the eight pages of the monitor will be discussed generally in this section and explained in more detail in the User's Manual, Appendix A.

1. Page 30₈ - Monitor Code

This page contains the program for listing the commands acceptable to the monitor, and monitor responses to those commands. The list below is a sample that is printed on the teletype in response to the command "C" given to the monitor.

```
S = STORE PROG.  
L = LOAD # PROG.  
M = LOAD MONITOR  
T = LIST TAPE  
C = MONITOR CODE  
P = SCRATCHPAD  
R = ERASE AFTER #  
X = EXECUED  
E = TAPE ERROR  
N = STORE MONITOR  
? = NEXT COMMAND
```

2. Page 31₈ - List

This page contains the coding necessary to list the system library and associated numbers that are recorded on magnetic tape.

This list is easily appended or changed in order to add to the list (maximum of 15 may be listed) or make different lists for various tapes. Below is a sample output from the monitor's response to the request "T".

M = MONITOR
02 = EDITOR
03 = PAL III
04 = ODT LOW
05 = HELP BOOTSP.

3. Page 32₈ - Erase and Store Monitor

This page is the last of Section I that is not required for primary operation of the monitor. The Erase procedure changes the tape label to reflect that any number of files have been deleted as long as they are located concurrently at the end of the list of files.

The Store Monitor routine is utilized to record the monitor when a new master tape is being formed. The initial tape label is written during the recording of the monitor, thus initializing the tape.

4. Page 33₈ - Store, Clear and Teletype

This page contains the programs necessary to record a user program at the end of the tape file. User programs may be loaded anywhere in memory between 0₈ and 6577₈ to be recorded on tape. The monitor responds with the numbered position of the recorded program. To retrieve this same program the number must be retained. An "X" is then typed to indicate that the operation has been executed.

The clear procedure is used by the monitor to clear all system flags located in the data handling system and teletype.



The necessary routines for operation of the teletype by the user or the monitor are located on this page. They include:

(1) Carriage return and line feed subroutines; (2) Type subroutine; and (3) List subroutine. These allow the system to type characters one at a time or receive characters one at a time through the accumulator.

5. Page 34₈ - Monitor Utility

Utility routines are located on this page. These programs form the tape label in correct format and decide which branch is to be taken upon receiving a command from the teletype.

6. Page 35₈ - Tape Subroutines and Scratch Pad

All subroutines for operating the tape drive must be on the same page. Many of the subroutines reference others listed on this page, thus reducing the amount of indirect calls. These routines enable the user or monitor to record, read, rewind, write logical gaps, or search the tape for appropriate records. Table III, Appendix A, lists each subroutine, address, and use.

A PAD subprogram is used to locate the scratch pad area on tape. In response to the command "P" the monitor transfers control to this procedure and the scratch pad area is located. The program then is terminated allowing the user complete control of the tape system.

7. Page 36₈ - Load and Load Monitor

Any numbered record on tape may be loaded into the computer memory through the use of the "L" command. Transfer of control is

assumed by the Load program and the symbols "#?" are typed. The desired number is entered on the keyboard and a check against the tape label is performed to insure a proper request has been made; if not, an "E" is typed indicating an error. If the request is valid the designated program is loaded into memory between addresses 0_8 and 6577_8 .

The Monitor may be recalled in its entirety at any time by the command "M". Code is transferred to locations 0100_8 to 0141_8 and control is shifted to this bootstrap. The monitor is reloaded and control shifts to the Utility package on page 34_8 .

8. Page 37_8 - Recover and Binary Loader

If only the top page of the monitor remains the recover procedure will enable the user to regain the full monitor program.

The Binary loader is a PDP-8 package enabling the user to load desired programs at the proper address in memory. This package is fully described in Ref. 1 and 5.

D. PAL III ASSEMBLER MODIFICATION

The mnemonic codes for tape control are not included in the assembler's permanent symbol table. Table II lists the mnemonic codes for the data handling system and were added to the permanent symbol table as explained in Ref. 2.

IV. RECOMMENDATIONS

In any system design project additional features seem to be desired. Not all design requirements were incorporated into the monitor but are presented here as a possible addition to the present system.

A. REVISED TAPE LABEL FORMAT

The existing tape label format allows for only one number to be written. A new tape label containing more information is desirable. The tape reel number, date of tape production, and number of records present should be recorded in addition to the counter. When the tape is loaded and monitor activated initially, the label should be read and typed on the teletype informing the user that the tape is the correct one selected and that the monitor is ready for use.

B. SCRATCH PAD RETURN COMMAND

The current design of the monitor allows the user a designated area to be utilized as desired. Return to this area can be accomplished by programmed control and must be specified by the user as explained in The User Manual, Appendix A.

A more convenient method would be to add one more command to the monitor, performing the same task that the user must.

With each addition to the monitor it must be remembered that more memory is required and as a consequence user space is restricted. The design of such a monitor is a compromise at best and not all recommended changes may be feasible to incorporate.

APPENDIX A

PDP-8/S MONITOR USER'S MANUAL

This appendix lists step-by-step procedures for complete operation of the monitor system. Any special features or error messages are explained at the end of each section. Table III is presented as an aid in locating helpful input/output subroutines.

1. Initial Loading of Monitor

1. Power on all units
2. Load tape reel
3. Press Load and Ready switches on PI 1207 RW (tape is positioned to reflective marker)
4. Set 0100 in switch register; depress load address
5. Toggle in the bootstrap octal code listed in Appendix B
6. Set 0100 in switch register; depress load address
7. Depress start.

This activates the program and in turn the tape is positioned to read the monitor into the computer memory. After the tape has halted, depress the rewind selected on the PI 1207 RW.

2. Monitor Execution

1. Is monitor loaded? If not execute section 1
2. Set 7000 in switch register, depress load address
3. Depress start
4. A question mark is typed; if not check section 2, then re-execute section 1 and 2.

Once the monitor has been executed the order in which the pseudo commands are given depends entirely upon the user's desires.

It is suggested that the "T" and "C" be executed to insure that the correct numbers for system programs and the correct code for monitor operation is obtained. Future sections will be presented in a

logical manner as though a program were to be developed from beginning to end.

3. Pseudo Command "L" (Load a Program)

1. Type "L" on keyboard in response to monitor's "?"
2. Teletype responds with "#?"
3. Type 2 digit number corresponding to desired program (i.e., 02 to load the editor program)
4. Program is loaded or "E" is typed indicating number entered is larger than tape label file and program requested is nonexistent
5. An "X" is typed indicating operation is complete, tape is rewound and stopped
6. Depress stop
7. Set initial address of requested program in switch register, depress load address
8. Depress start.

If a system program is loaded the system manual should be consulted for correct operation. If a user program is loaded, the starting address will remain the same as programmed. Execution of any program is discussed in Ref. 1. It is not necessary to store any system program after use since a fresh copy is always available on tape. Other programs may be loaded over the current one. If an "E" is typed after the loading of the program, inspection of the tape controller register will indicate the type of error generated on the tape system. In this case retry by repeating section 3.

4. Pseudo Command "S" (Store a Program)

1. Load program from binary tape utilizing BIN loader as specified in Refs. 1 and 5.
2. Restart monitor in accordance with section 2.
3. Type "S" in response to "?"
4. Program is recorded and "X" is typed
5. "#xx" is typed indicating number assigned to recorded program. Symbols xx are filled with the two digit octal number
6. Rewind is initiated and tape halted.

The number returned is the only identification a program receives and must be retained. When it is desired to load the same program the number is typed in response to the "#?" generated by the load procedure. It is recommended that the ODT LOW (debugging) procedure be loaded prior to loading the binary tape of the user program. This will enable the user more flexibility in changing his routines without the necessity of repeating the programming effort.

5. Pseudo Command "M" (Load the Monitor)

1. Monitor in control in accordance with section 2
2. Type "M" in response to "?"
3. Monitor is loaded and executed.

An error will be indicated if a "?" is not typed and inspection of the tape controller register will indicate the error. In this case a manual rewind must be executed on the PI 1207 RW unit and address 0100 loaded and executed manually on the console.

If user programs destroyed all of the monitor except the top page of memory, the recover procedure may be initiated by setting 7600₈ into the switch register, depressing load address, and start. A manual rewind must be performed after the tape has halted. Execute the monitor as described by section 2. If all of the monitor was destroyed section 1 and 2 must be executed to restart the entire system.

6. Pseudo Command "R" (Erase Program from Tape)

1. Type "R" in response to "?"
2. Monitor responds with "#?"
3. Type the number of the first program that is desired to be removed from the tape file
4. Tape label is checked to insure it is greater than number entered. If not "E" is typed indicating improper input from keyboard
5. Tape label is rewritten reflecting new tape file and rewound
6. An "X" is typed indicating that the operation executed

Tapes are not random access devices and, as such, cannot have files deleted randomly. Only files at the end of the tape may be deleted. The number entered is the first record to be deleted, but all records following that will be deleted as well.

7. Pseudo Command "N" (Store Monitor)

1. Load monitor from paper tape as described in BIN procedure
2. Execute monitor as described in section 2
3. Type "N" in response to "?"
4. Monitor and initial tape label are recorded. Rewind procedure is executed.

The store monitor procedure should only be executed when forming a new master tape. A special procedure is required to initialize the tape label and record the monitor since the memory location and size is different than user or system programs.

8. Pseudo Command "P" (Scratch Pad)

1. Type "P" in response to "?"
2. Tape positioned to scratch pad area
3. Tape halts.

The user may now halt the monitor and begin using the tape as additional storage; however, the tape must be programmed in assembly



language or by subroutine jumps to the tape program listed in Table III. Examples of their usage are depicted in Appendix B.

9. Teletype Input/Output

Many schemes can be utilized to print or retrieve information using the teletype. Packed coding is described in Ref. 1, indicating the proper procedures needed to pack and unpack ASCII code. All schemes need the ability to read and write the characters desired. Three procedures are necessary for teletype operation. Their locations are listed in Table III and may be used by subroutine calls to receive into the accumulator information entered from the keyboard, type information placed in the accumulator, and a carriage return line feed routine for control.



TABLE III
INPUT/OUTPUT SUBROUTINES

SUBROUTINE TITLE	OCTAL ADDRESS	OPERATION
CRLF	6665	Carriage return and line feed
TYPE	6676	Print one character
LISN	6704	Receive one character
READY	7200	Delay until tape is ready
WRITE	7204	Set up for write operation
READ	7211	Set up for read operation
WRBOT	7217	Write beginning of tape
WREOR	7230	Write end of record
WREOF	7240	Write end of file
REWIND	7250	Rewind tape and halt at load point
FLABEL	7263	Find tape label
RDTLB	7277	Read tape label
WRTLb	7312	Write tape label
SEARCH	7324	Search tape for desired record

APPENDIX B PDP-8/S MONITOR LISTING

BOOTSTRAP

ADDRESS	CODE		MNEMONIC CODE	COMMENTS
			*0100	
0100	7300	BOOT,	CLA CLL	
0101	6714		PFRD	
0102	6701		PSSR	
0103	5102		JMP.-1	
0104	6732	S,	PCLR	
0105	6754		PSMS	
0106	7300		CLA CLL	
0107	6761		PSSS	
0110	0125		AND EOF	
0111	7650		SNA CLA	
0112	5107		JMP.-3	
0113	2126		ISZ C	
0114	5104		JMP S	
0115	7300		CLA CLL	
0116	6751		PRDS	
0117	6741		PSDF	
0120	5117		JMP.-1	
0121	3527		DCA I AD	
0122	2127		ISZ AD	
0123	5115		JMP.-6	
0124	7402		HLT	
0125	0010	EOF,	0010	
0126	7775	C,	7775	
0127	6000	AD,	6000	

MAIN MONITOR LISTING

			*6000	
6000	7300	CODE,	CLA CLL	/CLEAR AC & LINK
6001	6046		TLS	/CLEAR PRINT FLAG
6002	1253		TAD F	/LOAD BASE
6003	3252		DCA D	/STORE BASE
6004	1247		TAD CC	/LOAD COUNTER
6005	3250		DCA C	
6006	4644	J2,	JMS I CRLF	/CARRIAGE RETURN
6007	1245		TAD A	/LOAD -8
6010	3246		DCA B	/LOAD COUNTER
6011	1652	J1,	TAD I D	/LOAD 2 CHARACTERS
6012	4221		JMS TCP	/PRINT 2 CHARACTERS
6013	2252		ISZ D	/D=D+1
6014	2246		ISZ B	/SKIP WHEN LINE PRINTED
6015	5211		JMP J1	/RETURN
6016	2250		ISZ C	/SKIP WHEN ALL LISTED
6017	5206		JMP J2	/RETURN
6020	5651		JMP I MON	/RETURN TO MONITOR



6021	0000	TCP,	0	/SUBROUTINE TO PRINT 2 CHAR.
6022	3237		DCA B1	/STORE 2 CHARACTERS
6023	1237		TAD B1	/LOAD SAME CHARACTERS
6024	0241		AND C1	/MASK LAST 6 BITS
6025	7112		CLL RTR	/ROTATE 2 RIGHT
6026	7112		CLL RTR	/ "
6027	7112		CLL RTR	/ "
6030	1240		TAD C2	/GENERATE ASII
6031	4643		JMS I TYPE	/TYPE SUBROUTINE
6032	1237		TAD B1	/LOAD CHARACTERS
6033	0242		AND C3	/MASK FIRST 6 BITS
6034	1240		TAD C2	/GENERATE ASII
6035	4643		JMS I TYPE	/TYPE SUBROUTINE
6036	5621		JMP I TCP	/RETURN
6037	0000	B1,	0	/BUFFER
6040	0240	C2,	240	/ASII FOR SPACE
6041	7700	C1,	7700	/MASK FOR LAST 6 BITS
6042	0077	C3,	77	/MASK FOR FIRST 6 BITS
6043	6676	TYPE,	6676	
6044	6665	CRLF,	6665	
6045	7770	A,	7770	/-8
6046	0000	B,	0	/BUFFER
6047	7765	CC,	7765	/-11
6050	0000	C,	0	/BUFFER
6051	7000	MON,	7000	/MONITOR ADDRESS
6052	0000	D,	0	
6053	6054	F,	+.1	/ADDRESS OF E
6054	6300	E,	6300	/LIST OF CODE TO FOLLOW
6055	3500		3500	
6056	6364		6364	
6057	5762		5762	
6060	4500		4500	
6061	6062		6062	
6062	5747		5747	
6063	1600		1600	
6064	5400		5400	
6065	3500		3500	
6066	5457		5457	
6067	4144		4144	
6070	0003		0003	
6071	0060		0060	
6072	6257		6257	
6073	4716		4716	
6074	5500		5500	
6075	3500		3500	
6076	5457		5457	
6077	4144		4144	
610	0055		0055	
6101	5756		5756	
6102	5164		5164	
6103	5762		5762	
6104	6400		6400	
6105	3500		3500	

6106	5451	5451
6107	6364	6364
6110	0064	0064
6111	4160	4160
6112	4500	4500
6113	0000	0000
6114	4300	4300
6115	3500	3500
6116	5557	5557
6117	5651	5651
6120	6457	6457
6121	6200	6200
6122	4357	4357
6123	4445	4445
6124	6000	6000
6125	3500	3500
6126	6343	6343
6127	6241	6241
6130	6443	6443
6131	5000	5000
6132	6041	6041
6133	4400	4400
6134	6200	6200
6135	3500	3500
6136	4562	4562
6137	4163	4163
6140	4500	4500
6141	4146	4146
6142	6445	6445
6143	6203	6203
6144	7000	7000
6145	3500	3500
6146	4570	4570
6147	4543	4543
6150	6564	6564
6151	4544	4544
6152	0000	0000
6153	0000	0000
6154	4500	4500
6155	3500	3500
6156	6441	6441
6157	6045	6045
6160	0045	0045
6161	6262	6262
6162	5762	5762
6163	0000	0000
6164	5600	5600
6165	3500	3500
6166	6364	6364
6167	5762	5762
6170	4500	4500
6171	5557	5557
6172	5616	5616

6173	0000	0000
6174	3700	3700
6175	3500	3500
6176	5645	5645
6177	7064	7064
6200	0043	0043
6201	5755	5755
6202	5541	5541
6203	5644	5644

			*6204
6204	7300	LIST,	CLA CLL /CLEAR AC & LINK
6205	6046		TLS /CLEAR PRINT FLAG
6206	1257		TAD F /LOAD BASE
6207	3256		DCA D /STORE BASE
6210	1253		TAD CC /LOAD COUNTER
6211	3254		DCA C
6212	4650	J2,	JMS I CRLF /CARRIAGE RETURN
6213	1251		TAD A /LOAD -8
6214	3252		DCA B /LOAD COUNTER
6215	1656	J1,	TAD I D /LOAD 2 CHARACTERS
6216	4225		JMS TCP /PRINT 2 CHARACTERS
6217	2256		ISZ D /D=D+1
6220	2252		ISZ B /SKIP WHEN LINE PRINTED
6221	5215		JMP J1 /RETURN
6222	2254		ISZ C /SKIP WHEN ALL LISTED
6223	5212		JMP J2 /RETURN
6224	5655		JMP I MON /RETURN TO MONITPR
6225	0000	TCP,	0 /SUBROUTINE TO PRINT 2 CHAR.
6226	3243		DCA B1 /STORE 2 CHARACTERS
6227	1243		TAD B1 /LOAD SAME CHARACTERS
6230	0245		AND C1 /MASK LAST 6 BITS
6231	7112		CLL RTR /ROTATE 2 RIGHT
6232	7112		CLL RTR / "
6233	7112		CLL RTR / "
6234	1244		TAD C2 /GENERATE ASII
6235	4647		JMS I TYPE /TYPE SUBROUTINE
6236	1243		TAD B1 /LOAD CHARACTERS
6237	0246		AND C3 /MASK FIRST 6 BITS
6240	1244		TAD C2 /GENERATE ASII
6241	4647		JMS I TYPE /TYPE SUBROUTINE
6242	5625		JMP I TCP /RETURN
6243	0000	B1,	0 /BUFFER
6244	0240	C2,	240 /ASII FOR SPACE
6245	7700	C1,	7700 /MASK FOR LAST 6 BITS
6246	0077	C3,	77 /MASK FOR FIRST 6 BITS
6247	6676	TYPE,	6676
6250	6665	CRLF,	6665
6251	7770	A,	7770 /-8
6252	0000	B,	0 /BUFFER
6253	7773	CC,	7773 /-5
6254	0000	C,	0 /BUFFER
6255	7000	MON,	7000 /MONITOR ADDRESS

6256	0000	D,	0	
6257	6260	F,	..+1	/ADDRESS OF E
6260	5500	E,	5500	/LIST OF PROG. ON TAPE FOLLOWS
6261	0035		0035	
6262	0055		0055	
6263	5756		5756	
6264	5164		5164	
6265	5762		5762	
6266	0000		0000	
6267	0000		0000	
6270	2022		2022	
6271	0035		0035	
6272	0045		0045	
6273	4451		4451	
6274	6457		6457	
6275	6200		6200	
6276	0000		0000	
6277	0000		0000	
6300	2023		2023	
6301	0035		0035	
6302	0060		0060	
6303	4154		4154	
6304	0051		0051	
6305	5151		5151	
6306	0000		0000	
6307	0000		0000	
6310	2024		2024	
6311	0035		0035	
6312	0057		0057	
6313	4464		4464	
6314	0054		0054	
6315	5767		5767	
6316	0000		0000	
6317	0000		0000	
6320	2025		2025	
6321	0035		0035	
6322	0050		0050	
6323	4554		4554	
6324	6000		6000	
6325	4257		4257	
6326	5764		5764	
6327	6360		6360	

			*6440
6440	7300	STOREM,	CLA CLL /CLEAR AC & LINK
6441	1357		TAD M /LOAD TAPE LABEL
6442	3753		DCA I BUF /STORE
6443	1360		TAD A /START ADDRESS
6444	3361		DCA B /STORE
6445	4762		JMS I WRBOT
6446	4755		JMS I WREOF
6447	4747		JMS I WRTLB
6450	4754		JMS I WREOR

6451	4755	JMS I WREOF
6452	4762	JMS I WRBOT
6453	4755	JMS I WREOF
6454	4763	JMS I WRITE
6455	6754	PSMS /SLEW MODE SELECT
6456	4764	JMS I READY
6457	7300	CLA CLL /CLEAR AC & LINK
6460	1761	TAD I B /LOAD WORD
6461	6744	PLDS /WRITE WORD
6462	6741	ISDF /SKIP ON DATA FLAG
6463	5262	JMP.-1 /JUMP
6464	2361	ISZ B /INC. & SKIP ADDRESS
6465	5257	JMP.-6 /JUMP
6466	4754	JMS I WREOR
6467	4755	JMS I WREOF
6470	4750	JMS I REWIND
6471	4756	JMS I TYPEX
6472	5741	JMP I MON /RETURN TO MONITOR
6473	7300	ERASE, CLA CLL /CLEAR AC & LINK
6474	6046	TLS /CLEAR PRINT FLAG
6475	4743	JMS I CRLF
6476	7300	CLA CLL
6477	1336	TAD SIGN /"#"
6500	4742	JMS I TYPE
6501	1337	TAD QUE /"?"
6502	4742	JMS I TYPE
6503	4743	JMS I CRLF
6504	4744	JMS I FORML
6505	4745	JMS I FLABEL
6506	4746	JMS I RDTLB
6507	4750	JMS I REWIND
6510	1751	TAD I LABEL /LOAD LABEL
6511	7041	CIA /2'S COMP.
6512	1752	TAD I KEY /ADD KEY
6513	7710	SPA CLA /SKIP IF AC>=0; CLEAR
6514	5326	JMP ERR /JUMP TO ERROR ROUTINE
6515	1751	TAD I LABEL /LOAD LABEL
6516	3753	DCA I BUF /STORE LABEL
6517	4745	JMS I FLABEL
6520	4747	JMS I WRTLB
6521	4754	JMS I WREOR
6522	4755	JMS I WREOF
6523	4750	JMS I REWIND
6524	4756	JMS I TYPEX
6525	5741	JMP I MON /RETURN TO MONITOR
6526	7300	ERR, CLA CLL
6527	6046	TLS /CLEAR PRINT FLAG
6530	4743	JMS I CRLF
6531	7300	CLA CLL
6532	1340	TAD E /"E"
6533	4742	JMS I TYPE
6534	4743	JMS I CRLF
6535	5741	JMP I MON /RETURN TO MONITOR

6536	0243	SIGN,	0243	/"#"
6537	0277	QUE,	0277	/"?"
6540	0305	E,	0305	/"E"
6541	7000	MON,	7000	/ADDRESS OF MONITOR
6542	6676	TYPE,	6676	
6543	6665	CRLF,	6665	
6544	7063	FORML,	7063	
6545	7263	FLABEL,	7263	
6546	7277	RDTLB,	7277	
6547	7312	WRTLB,	7312	
6550	7250	REWIND,	7250	
6551	7753	LABEL,	7753	
6552	7755	KEY,	7755	
6553	7754	BUF,	7754	
6554	7230	WREOR,	7230	
6555	7240	WREOF,	7240	
6556	7052	TYPEX,	7052	
6557	0003	M,	0003	/TAPE LABEL
6560	6000	A,	6000	/START ADDRESS
6561	0000	B,	0000	/BUFFER
6562	7217	WRBOT,	7217	
6563	7204	WRITE,	7204	
6564	7200	READY,	7200	

		*6600	
6600	7300	STORE,	CLA CLL /CLEAR AS & LINK
6601	4655		JMS I FLABEL
6602	4656		JMS I RDTLB
6603	4654		JMS I REWIND
6604	7201		CLA IAC /AC=1
6605	1647		TAD I KEY /BUMP COUNTER
6606	3647		DCA I KEY /STORE
6607	1647		TAD I KEY /LOAD
6610	3646		DCA I BUF /STORE
6611	4655		JMS I FLABEL
6612	4657		JMS I WRTLB
6613	4660		JMS I WREOR
6614	4661		JMS I WREOF
6615	4654		JMS I REWIND
6616	4662		JMS I SEARCH
6617	1244		TAD A /LOAD START ADDRESS
6620	3245		DCA AD /STORE
6621	4663		JMS I WRITE
6622	6754		PSMS /SLEW MODE SELECT
6623	4664		JMS I READY
6624	7300	WW,	CLA CLL
6625	1645		TAD I AD /LOAD WORD
6626	6744		PLDS /WRITE WORD
6627	6741		PSDF /SKIP ON DATA FLAG
6630	5227		JMP.-1 /JUMP
6631	2245		ISZ AD /INC. ADDRESS
6632	1245		TAD AD /LOAD ADDRESS
6633	1250		TAD COUNT /LOAD TOP ADDRESS

6634	7640		SZA CLA /SKIP AC=0; CLEAR
6635	5224		JMP WW /JUMP
6636	4660		JMS I WREOR
6637	4661		JMS I WREOF
6640	4654		JMS I REWIND
6641	4652		JMS I TYPEX
6642	4653		JMS I NUMBER
6643	5651		JMP I MON /RETURN TO MONITOR
6644	0000	A,	0000 /START ADDRESS
6645	0000	AD,	0000 /BUFFER
6646	7754	BUF,	7754 /ADDRESS OF BUF
6647	7755	KEY,	7755 /ADDRESS OF KEY
6650	1200	COUNT,	1200 /TOP ADDRESS
6651	7000	MON,	7000 /ADDRESS OF MONITOR
6652	7052	TYPEX,	7052 /TYPE"X"
6653	7103	NUMBER,	7103
6654	7250	REWIND,	7250
6655	7263	FLABEL,	7263
6656	7277	RDTLB,	7277
6657	7312	WRTLb,	7312
6660	7230	WREOR,	7230
6661	7240	WREOF,	7240
6662	7324	SEARCH,	7324
6663	7204	WRITE,	7204
6664	7200	READY,	7200
6665	0000	CRLF,	0 /CARRIAGE RETURN LINE FEED
6666	7300		CLA CLL /CLEAR AC & LINK
6667	1274		TAD C3 /LOAD C.R.
6670	4276		JMS TYPE /TYPE
6671	1275		TAD C4 /LOAD L.F.
6672	4276		JMS TYPE /TYPE
6673	5665		JMP I CRLF /RETURN
6674	0215	C3,	0215 /CARRIAGE RETURN
6675	0212	C4,	0212 /LINE FEED
6676	0000	TYPE,	0 /TYPE SUBROUTINE
6677	6041		TSF /SKIP IF FLAG SET
6700	5277		JMP.-1 /JUMP
6701	6046		TLS /PRINT
6702	7300		CLA CLL /CLEAR AC & LINK
6703	5676		JMP I TYPE /RETURN
6704	0000	LISN,	0 /ACCEPT CHARACTER SUBROUTINE
6705	6031		KSF
6706	5305		JMP.-1
6707	6036		KRB
6710	6046		TLS
6711	5704		JMP I LISN /RETURN
6712	0000	CLEAR,	0 /CLEAR SYS.
6713	7300		CLA CLL /CLEAR AC & LINK
6714	6714		PFRD /FWD. SEL. READ
6715	6736		PCHLT /CLEAR TAPE
6716	6714		PFRD
6717	6736		PCHLT
6720	6701		PSSR /SKIP IF SYS. READY

6721	5320		JMP.-1 /JUMP
6722	7300		CLA CLL
6723	5712		JMP I CLEAR /RETURN
*7000			
7000	4777	MON,	JMS I CLEAR /CLEAR SYS.
7001	6046	A,	TLS /CLEAR PRINT FLAG
7002	4764		JMS I CRLF /CRLF
7003	1341	B,	TAD C1 /LOAD "?"
7004	4765		JMS I TYPE /TYPE
7005	4764		JMS I CRLF /CRLF
7006	4766		JMS I LISN /LISN
7007	3336		DCA B1 /STORE CHARACTER
7010	4764		JMS I CRLF /CRLF
7011	1336		TAD B1
7012	1342		TAD C2
7013	7650		SNA CLA /SKIP IF NOT "L"
7014	5767		JMP I LOAD /LOAD ROUTINE
7015	1336		TAD B1
7016	1343		TAD C3
7017	7650		SNA CLA /SKIP IF NOT "S"
7020	5770		JMP I STORE /STORE ROUTINE
7021	1336		TAD B1
7022	1344		TAD C4
7023	7650		SNA CLA /SKIP IF NOT "M"
7024	5771		JMP I LMON /LOAD MONITOR ROUTINE
7025	1336		TAD B1
7026	1345		TAD C5
7027	7650		SNA CLA /SKIP IF NOT "T"
7030	5772		JMP I LIST /LIST PROG. ON TAPE
7031	1336		TAD B1
7032	1346		TAD C6
7033	7650		SNA CLA /SKIP IF NOT "C"
7034	5773		JMP I CODE /LIST CODE ROUTINE
7035	1336		TAD B1
7036	1347		TAD C7
7037	7650		SNA CLA /SKIP IF NOT "P"
7040	5774		JMP I PAD /SCRATCH PAD ROUTINE
7041	1336		TAD B1
7042	1350		TAD C8
7043	7650		SNA CLA /SKIP IF NOT "R"
7044	5775		JMP I ERASE /ERASE ROUTINE
7045	1336		TAD B1
7046	1351		TAD C9
7047	7650		SNA CLA /SKIP IF NOT "N"
7050	5776		JMP I STOREM /STORE MONITOR ROUTINE
7051	5203		JMP B /ASK FOR COMMAND
7052	0000	TYPEX,	0 /TYPE EXECUTED ROUTINE
7053	7300		CLA CLL /CLEAR AC & LINK
7054	6046		TLS /CLEAR PRINT FLAG
7055	4764		JMS I CRLF /CRLF
7056	7300		CLA CLL
7057	1352		TAD C10 /LOAD "X"
7060	4765		JMS I TYPE

7061	4764		JMS I CRLF
7062	5652		JMP I TYPEX /RETURN
7063	0000	FORML,	0 /FORM LABEL ROUTINE
7064	4766		JMS I LISN
7065	1356		TAD M260 /STRIP
7066	3336		DCA B1 /STORE
7067	4766		JMS I LISN
7070	1356		TAD M260 /STRIP
7071	3337		DCA B2 /STORE
7072	4764		JMS I CRLF
7073	1336		TAD B1 /LOAD
7074	7104		CLL RAL /SHIFT LEFT 1
7075	7104		CLL RAL
7076	7104		CLL RAL
7077	1337		TAD B2 /FORM CHAR.
7100	1354		TAD K /ADD 2
7101	3763		DCA I LABEL /STORE
7102	5663		JMP I FORML /RETURN
7103	0000	NUMBER,	0 /TYPE PROG. #
7104	6046		TLS /CLEAR PRINT FLAG
7105	4764		JMS I CRLF
7106	1762		TAD I KEY /LOAD COUNT
7107	1355		TAD MK /ADD -2
7110	3336		DCA B1 /STORE
7111	1336		TAD B1 /LOAD
7112	0360		AND MASK1 /STRIP
7113	7110		CLL RAR /SHIFT RIGHT 1
7114	7110		CLL RAR
7115	7110		CLL RAR
7116	1357		TAD K260 /FORM ASCII
7117	3337		DCA B2 /STORE
7120	1336		TAD B1 /LOAD
7121	0361		AND MASK2 /STRIP
7122	1357		TAD K260 /FORM ASCII
7123	3340		DCA B3 /STORE
7124	6046		TLS
7125	1353		TAD C11 /"?"
7126	4765		JMS I TYPE /TYPE
7127	7300		CLA CLL
7130	1337		TAD B2 /LOAD 1ST #
7131	4765		JMS I TYPE
7132	7300		CLA CLL
7133	1340		TAD B3 /LOAD 2ND #
7134	4765		JMS I TYPE
7135	5703		JMP I NUMBER /RETURN
7136	0000	B1,	0000 /BUFFER
7137	0000	B2,	0000
7140	0000	B3,	0000
7141	0277	C1,	0277 /"?"
7142	7464	C2,	7464 /MOD "L"
7143	7455	C3,	7455 /MOD "S"
7144	7463	C4,	7463 /MOD "M"
7145	7454	C5,	7454 /MOD "T"

7146	7475	C6,	7475	/MOD "C"
7147	7460	C7,	7460	/MOD "P"
7150	7456	C8,	7456	/MOD "R"
7151	7462	C9,	7462	/MOD "N"
7152	0330	C10,	0330	/"X"
7153	0243	C11,	0243	/"#"
7154	0002	K,	0002	/+2
7155	7776	MK,	7776	/-2
7156	7520	M260,	7520	/-260
7157	0260	K260,	0260	/+260
7160	0070	MASK1,	0070	/10'S MASK
7161	0007	MASK2,	0007	/1'S MASK
7162	7755	KEY,	7755	/KEY
7163	7753	LABEL,	7753	/LABEL
7164	6665	CP' F,	6665	
7165	6676	TYPE,	6676	
7166	6704	LISN,	6704	
7167	7467	LOAD,	7467	
7170	6600	STORE,	6600	
7171	7400	LMON,	7400	/LOAD MONITOR
7172	6204	LIST,	6204	/LIST PROG. ON TAPE
7173	6000	CODE,	6000	/CODE FOR MONITOR
7174	7350	PAD,	7350	
7175	6473	ERASE,	6473	
7176	6440	STOREM,	6440	/STORE MONITOR
7177	6712	CLEAR,	6712	

			*7200	
7200	0000	READY,	0	/READY SUBROUTINE
7201	6701		PSSR	/SKIP IF SYSTEM READY
7202	5201		JMP.-1	/JUMP
7203	5600		JMP I READY	/RETURN
7204	0000	WRITE,	0	/SET UP FOR WRITE SUBROUTINE
7205	7300		CLA CLL	/CLEAR AC & LINK
7206	6702		PWMS	/WRITE MODE SELECT
7207	4200		JMS READY	/READY
7210	5604		JMP I WRITE	/RETURN
7211	0000	READ,	0	/SET UP FOR READ SUBROUTINE
7212	6736		PCHLT	/CLEAR FLAGS
7213	4200		JMS READY	/READY
7214	6714		PFRD	/FWD. SELECT READ
7215	4200		JMS READY	/READY
7216	5611		JMP I READ	/RETURN
7217	0000	WRBOT,	0	/WRITE BOT SUBROUTINE
7220	7300		CLA CLL	/CLEAR AC & LINK
7221	4204		JMS WRITE	/WRITE
7222	6704		PBOT	/WRITE BOT
7223	6741		PSDF	/SKIP ON DATA FLAG
7224	5223		JMP.-1	/JUMP
7225	6736		PCHLT	/CLEAR FLAGS
7226	4200		JMS READY	
7227	5617		JMP I WRBOT	/RETURN
7230	0000	WREOR,	0	/WRITE EOR SUBROUTINE

7231	7300		CLA CLL /CLEAR AC & LINK
7232	4204		JMS WRITE /WRITE
7233	6771		PEOR /WRITE EOR
7234	6741		PSDF /SKIP ON DATA FLAG
7235	5234		JMP.-1 /JUMP
7236	4200		JMS READY
7237	5630		JMP I WREOR /RETURN
7240	0000	WREOF,	0 /WRITE EOF SUBROUTINE
7241	7300		CLA CLL /CLEAR AC & LINK
7242	4204		JMS WRITE /WRITE
7243	6722		PEOF /WRITE EOF
7244	6741		PSDF /SKIP ON DATA FLAG
7245	5244		JMP.-1 /JUMP
7246	4200		JMS READY /READY
7247	5640		JMP I WREOF /RETURN
7250	0000	REWIND,	0 /REWIND SUBROUTINE
7251	4211		JMS READ /READ
7252	6764		PREW /REWIND & LOAD
7253	6761		PSSS /SENSE SYS. STATUS
7254	0262		AND BOT /BOT MASK
7255	7650		SNA CLA /SKIP AC NOT = 0; CLEAR
7256	5253		JMP.-3 /JUMP
7257	6736		PCHLT /CLEAR FLAGS
7260	4200		JMS READY /READY
7261	5650		JMP I REWIND /RETURN
7262	0100	BOT,	0100 /BOT,LOAD POINT MASK
7263	0000	FLABEL,	0 /FIND TAPE LABEL SUBROUTINE
7264	4211		JMS READ /READ ROUTINE
7265	6754		PSMS /SLEW MODE SEL.
7266	4200		JMS READY
7267	7300		CLA CLL
7270	6761		PSSS /SENSE SYS. STATUS
7271	0347		AND EOF /EOF MASK
7272	7650		SNA CLA /SKIP AC NOT = 0; CLEAR
7273	5270		JMP.-3
7274	6736		PCHLT
7275	4200		JMS READY
7276	5663		JMP I FLABEL /RETURN
7277	0000	RDTLB,	0 /READ TAPE LABEL SUBROUTINE
7300	4211		JMS READ /READ ROUTINE
7301	6754		PSMS /SLEW MODE SELECT
7302	7300		CLA CLL /CLEAR AC & LINK
7303	6751		PRDS /READ LABEL
7304	6741		PSDF /SKIP ON DATA FLAG
7305	5304		JMP.-1 /JUMP
7306	3746		DCA I KEY /STORE LABEL
7307	6736		PCHLT /CLEAR FLAGS
7310	4200		JMS READY /READY
7311	5677		JMP I RDTLB /RETURN
7312	0000	WRTLB,	0 /WRITE TAPE LABEL SUBROUTINE
7313	4204		JMS WRITE /WRITE ROUTINE
7314	6754		PSMS /SLEW MODE SELECT
7315	1745		TAD I BUF /LOAD NEW LABEL

7316	6744		PLDS	/LOAD DATA BUFFER & STEP
7317	6741		PSDF	/SKIP ON DATA FLAG
7320	5317		JMP.-1	/JUMP
7321	6736		PCHLT	/CLEAR FLAG
7322	4200		JMS READY	/READY
7323	5712		JMP I WRTLB	/RETURN
7324	0000	SEARCH,	0	/SEARCH SUBROUTINE
7325	1746		TAD I KEY	/LOAD KEY COUNTER
7326	7041		CIA	/2'S COMP.
7327	3746		DCA I KEY	/STORE COUNTER
7330	4211		JMS READ	/READ
7331	6772		PHAS	/HI SPEED SELECT
7332	4200		JMS READY	/READY
7333	7300	GAP,	CLA CLL	/CLEAR AC & LINK
7334	6761		PSSS	/SENSE SYS. STATUS
7335	0347		AND EOF	/AND EOF MASK
7336	7650		SNA CLA	/SKIP AC NOT =0; CLEAR
7337	5334		JMP.-3	/JUMP
7340	2746		ISZ I KEY	/BUMP COUNTER
7341	5333		JMP GAP	/JUMP
7342	6736		PCHLT	/CLEAR FLAG
7343	4200		JMS READY	/READY
7344	5724		JMP I SEARCH	/RETURN
7345	7754	BUF,	7754	/LABEL
7346	7755	KEY,	7755	/ADDRESS
7347	0010	EOF,	0010	/SET BIT 8 TO 1
7350	7300	PAD,	CLA CLL	/CLEAR AC & LINK
7351	1367		TAD T	/LOAD COUNT
7352	3372		DCA TT	/STORE
7353	4263		JMS FLABEL	/FIND LABEL
7354	4277		JMS RDTLB	/READ TAPE LABEL
7355	4250		JMS REWIND	/REWIND
7356	7201		CLA IAC	/AC=1
7357	1746		TAD I KEY	/LOAD KEY
7360	3746		DCA I KEY	/STORE
7361	4324		JMS SEARCH	/SEARCH
7362	4217		JMS WRBOT	/WRITE BOT
7363	2372		ISZ TT	/INC. & SKIP
7364	5362		JMP.-2	/JUMP
7365	4240		JMS WREOF	/EOF
7366	5771		JMP I MON	/RETURN TO MONITOR
7367	7742	T,	7742	/-30
7370	7777	L,	7777	/-1
7371	7000	MON,	7000	/MONITOR
7372	0000	TT,	0000	/BUFFER

*7400

7400	7300	LMON,	CLA CLL	/CLEAR AC & LINK
7401	1223		TAD S	/LOAD START ADDRESS
7402	3222		DCA SS	/STORE
7403	1216		TAD P	/LOAD NEW ADDRESS
7404	3217		DCA PP	/STORE
7405	1220		TAD C	/LOAD WORD COUNT

7406	3221		DCA CC	/STORE
7407	1622		TAD I SS	/LOAD WORD
7410	3617		DCA I PP	/STORE
7411	2222		ISZ SS	/INC. ADDRESS
7412	2217		ISZ PP	/ " "
7413	2221		ISZ CC	/BUMP COUNTER
7414	5207		JMP.-5	/JUMP
7415	5616		JMP I P	/CONTROL TO LMON
7416	0100	P,	0100	/NEW ADDRESS
7417	0000	PP,	0000	/BUFFER
7420	7735	C,	7735	/COUNTER
7421	0000	CC,	0000	/BUFFER
7422	0000	SS,	0000	/BUFFER
7423	7424	S,	.+1	/ADDRESS OF NN
7424	7300	NN,	7300	/START CODE HERE
7425	1130		1130	
7426	3531		3531	
7427	4536		4536	
7430	1132		1132	
7431	3133		3133	
7432	4537		4537	
7433	6754		6754	
7434	4542		4542	
7435	7300		7300	
7436	6751		6751	
7437	6741		6741	
7440	5113		5113	
7441	3533		3533	
7442	2133		2133	
7443	5111		5111	
7444	7300		7300	
7445	6761		6761	
7446	0134		0134	
7447	7640		7640	
7450	7402		7402	
7451	4535		4535	
7452	4540		4540	
7453	5541		5541	
7454	0003		0003	
7455	7755		7755	
7456	6000		6000	
7457	0000		0000	
7460	7610		7610	
7461	7250		7250	
7462	7324		7324	
7463	7211		7211	
7464	7052		7052	
7465	7000		7000	
7466	7200		7200	
7467	7300	LOAD,	CLA CLL	/CLEAR AC & LINK
7470	6046		TLS	/CLEAR PRINT FLAG
7471	4774		JMS I CRLF	/CRLF
7472	7300		CLA CLL	/CLEAR AC & LINK

7473	1360		TAD SIGN	/"#"
7474	4775		JMS I TYPE	/TYPE
7475	1361		TAD QUE /"?"	
7476	4775		JMS I TYPE	/TYPE
7477	4774		JMS I CRLF	/CRLF
7500	4772		JMS I FORML	/FORM LABEL
7501	4766		JMS I FLABEL	/FIND LABEL
7502	4767		JMS I RDTLB	/READ TAPE LABEL
7503	4765		JMS I REWIND	/REWIND
7504	1764		TAD I LABEL	/LOAD LABEL
7505	7041		CIA	/2'S COMP.
7506	1763		TAD I KEY	/LOAD TAPE LABEL
7507	7710		SPA CLA /SKIP IF AC>=0; CLEAR	
7510	5344		JMP ERROR	/ERROR ROUTINE
7511	1764		TAD I LABEL	/LOAD CORRECT LABEL
7512	3763		DCA I KEY	/STORE
7513	4770		JMS I SEARCH	/SEARCH
7514	1354		TAD A	/LOAD START ADDRESS
7515	3355		DCA AD	/STORE
7516	4771		JMS I READ	/READ
7517	6754		PSMS	/SLEW MODE SELECT
7520	4777		JMS I READY	
7521	7300		CLA CLL /CLEAR AC & LINK	
7522	6751	RR,	PRDS	/READ
7523	6741		PSDF	/SKIP ON DATA FLAG
7524	5323		JMP.-1	/JUMP
7525	3755		DCA I AD	/STORE WORD
7526	2355		ISZ AD	/INC. ADDRESS
7527	1355		TAD AD	/LOAD ADDRESS
7530	1356		TAD COUNT	/LOAD TOP ADDRESS
7531	7640		SZA CLA /SKIP AC=0; CLEAR	
7532	5322		JMP RR	/JUMP
7533	7300		CLA CLL /CLEAR AC & LINK	
7534	6761		PSSS	/SENSE SYS. STATUS
7535	0357		AND MSK	/ERROR MASK
7536	7640		SZA CLA /SKIP AC=0; CLEAR	
7537	5343		JMP ERR	/JUMP
7540	4765		JMS I REWIND	/REWIND
7541	4773		JMS I TYPEX	/TYPE "X"
7542	5776		JMP I MON	/RETURN TO MONITOR
7543	4765	ERR,	JMS I REWIND	
7544	7300	ERROR,	CLA CLL	
7545	6046		TLS	/CLEAR PRINT FLAG
7546	4774		JMS I CRLF	/CRLF
7547	7300		CLA CLL /CLEAR AC & LINK	
7550	1362		TAD E	/LOAD "E"
7551	4775		JMS I TYPE	/TYPE
7552	4774		JMS I CRLF	/CRLF
7553	5776		JMP I MON	/RETURN TO MONITOR
7554	0000	A,	0000	/START ADDRESS
7555	0000	AD,	0000	/BUFFER
7556	1200	COUNT,	1200	/COUNTER
7557	7610	MSK,	7610	/ERROR MASK

7560	0243	SIGN,	0243	/"#"
7561	0277	QUE,	0277	/"?"
7562	0305	E,	0305	/"E"
7563	7755	KEY,	7755	/ADDRESS OF KEY
7564	7753	LABEL,	7753	/ADDRESS OF LABEL
7565	7250	REWIND,	7250	
7566	7263	FLABEL,	7263	
7567	7277	RDTLB,	7277	
7570	7324	SEARCH,	7324	
7571	7211	READ,	7211	
7572	7063	FORML,	7063	
7573	7052	TYPEX,	7052	
7574	6665	CRLF,	6665	
7575	6676	TYPE,	6676	
7576	7000	MON,	7000	/MONITOR
7577	7200	READY,	7200	

			*7600	
7600	7300	RECOV,	CLA CLL	/CLEAR AC & LINK
7601	6714		PFRD	/FWD. SEL. READ
7602	6701		PSSR	/SKIP IF SYS. READY
7603	5202		JMP.-1	/JUMP
7604	6732	S,	PCLR	/CLEAR STATUS REG.
7605	6754		PSMS	/SLEW MODE SEL.
7606	7300		CLA CLL	
7607	6761		PSSS	/SENSE SYS. STATUS
7610	0367		AND EOF	/EOF MASK
7611	7650		SNA CLA	/SKIP AC NOT = 0; CLEAR
7612	5207		JMP.-3	/JUMP
7613	2370		ISZ C	/INC. & COUNT
7614	5204		JMP S	/AGAIN
7615	5356		JMP CONT	/CONTINUE
7616	0000		0000	
7617	0000		0000	
7620	0000		0000	
7621	0000		0000	
7622	0000		0000	
7623	0000		0000	
7624	0000		0000	
7625	7402	BIN,	7402	
7626	0000		0000	
7627	3212		3212	
7630	4260		4260	
7631	1300		1300	
7632	7700		7750	
7633	5237		5237	
7634	2212		2212	
7635	7040		7040	
7636	5227		5227	
7637	1212		1212	
7640	7640		7640	
7641	5230		5230	
7642	1214		1214	

7643	0274	0274
7644	1341	1341
7645	7510	7510
7646	2226	2226
7647	7750	7750
7650	5626	5626
7651	1214	1214
7652	0256	0256
7653	1257	1257
7654	3213	3213
7655	5230	5230
7656	0070	0070
7657	6201	6201
7660	7631	7631
7661	5262	5262
7662	6031	6031
7663	5262	5262
7664	6036	6036
7665	3214	3214
7666	1214	1214
7667	5660	5660
7670	6011	6011
7671	5270	5270
7672	6016	6016
7673	5265	5265
7674	0300	0300
7675	4343	4343
7676	7041	7041
7677	1215	1215
7700	7402	7402
7701	6032	6032
7702	6014	6014
7703	6214	6214
7704	1257	1257
7705	3213	3213
7706	7604	7604
7707	7700	7700
7710	1353	1353
7711	1352	1352
7712	3261	3261
7713	4226	4226
7714	5313	5313
7715	3215	3215
7716	1213	1213
7717	3336	3336
7720	1214	1214
7721	3376	3376
7722	4260	4260
7723	3355	3355
7724	4226	4226
7725	5275	5275
7726	4343	4343
7727	7420	7420

7730	5336		5336
7731	3216		3216
7732	1376		1376
7733	1355		1355
7734	1215		1215
7735	5315		5315
7736	6201		6201
7737	3616		3616
7740	2216		2216
7741	7600		7600
7742	5332		5332
7743	7676		7676
7744	1376		1376
7745	7106		7106
7746	7006		7006
7747	7006		7006
7750	1355		1355
7751	5743		5743
7752	5262		5262
7753	0000	LABEL,	0000
7754	0000	BUF,	0000
7755	0003	KEY,	0003
7756	7300	CONT,	CLA CLL /CLEAR AC & LINK
7757	6751		PRDS /READ
7760	6741		PSDF /SKIP ON DATA FLAG
7761	5360		JMP.-1 /JUMP
7762	3771		DCA I AD /STORE WORD
7763	2371		ISZ AD /INC. ADDRESS
7764	2372		ISZ WCNT /INC. & SKIP WORD CNT.
7765	5356		JMP.-7 /JUMP
7766	7402		HLT /HALT
7767	0010	EOF,	0010 /EOF MASK
7770	7775	C,	7775 /-3
7771	6000	AD,	6000 /START ADDRESS
7772	1600	WCNT,	1600 /WORD COUNT
7773	0000		0000
7774	0000		0000
7775	0000		0000
7776	0000		0000
7777	5301		5301

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<p>The design and implementation of the PDP-8/S Monitor is described. The monitor is an interactive tape driving routine combined with a small operating system. The monitor was implemented in PAL III, the PDP-8 assembly language, for operation in conjunction with a teletype and PI-1250-1 Data Handling System.</p>			

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Martinsen

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